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United States Army
Corps of Engineers

Alaska District
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FUDS Site Closeout Report

Pedro Dome Radio Relay Station
Fox, Alaska

March 27, 2002
USACE-POA-EN-EE (Haviland)
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1. Introduction

This report has been prepared to evaluate the completion of the cleanup conducted between 1991 and 1999 at the former Pedro Dome Radio Relay Station (RRS) near Fox, Alaska, and to determine if further work is required. This report is also intended to satisfy the requirements for an Application for Risk-Based Closure of the Formerly Used Defense Site (FUDS) Pedro Dome Radio Relay Station, Fox, Alaska, under PCB Remediation Waste Under 40 CFR § 761.61(c). The United States Army Corps of Engineers (USACE), Alaska District (POA), accomplished the work, at the site. The Defense Environmental Restoration Program for Formerly Used Defense Sites (DERP-FUDS) authorizes the cleanup of contamination and unsafe debris resulting from past military activities at sites no longer owned by the Department of Defense. This report supports the conclusion that the work performed between 1991 and 1999 is complete, and that no further action is required at the site to be protective of human health and the environment from past activities by the Department of Defense.

The principal contaminants of concern at the Pedro Dome Site were polychlorinated biphenyls (PCBs), and asbestos containing materials (ACM). No other contaminants were identified which would pose a threat to human health or the environment. About 800 cubic yards of PCB contaminated soil were excavated and disposed of at the EnviroSafe Services Environmental Protection Agency (EPA) permitted landfill in Grandview, Idaho. Steel from the water tank demolition was recycled. Demolition debris from the water tank and pump house was landfilled at the Fairbanks North Star Borough (FNSB) state permitted landfill in Fairbanks, Alaska. Approximately 600 pounds of ACM asphalt shingles from the water tank and 47 linear feet of water line with ACM insulation was removed and disposed of at the FNSB landfill.

2. Summary of Site Conditions

2.1 Site Location and Description

The former Pedro Dome RRS is located approximately 2,600 feet above sea level, at the summit of Pedro Dome near Fairbanks, Alaska. Pedro Dome is approximately 18 miles north of Fairbanks. The entrance to the approximately 2 1/2 – mile-long access road is located at Cleary Summit, near mile 22 of the Steese Highway (See figures 1, 2 and 5). The twenty-five acre site (Tract A) is located within a 3,265-acre parcel owned by the State of Alaska (Figure 3). The 3,265-acre parcel is listed as undeveloped land (S&W 1997). Pedro Dome lies at approximately 65d 02m North Latitude, 147d 30m West Longitude (Section 2, T2N, R1E, Fairbanks Meridian). The nearest population center is Fox, located at mile 11 Steese Highway. Fox is an unincorporated city with a population of 300 (2000 U.S. Census). At the intersection of Pedro Dome Road and the Steese Highway (about 2 miles straight line distance from the site) are 10 to 12 dwellings. Most of them appear to be second homes, not permanent residences (USACE 1997b). Interior Alaska experiences seasonal temperature extremes. Average annual precipitation is 11.3 inches. Ice fog is common during the winter. January temperatures range from -22 to -2;

July temperatures range from 50 to 72. Monthly temperatures and windspeeds for Fairbanks are shown in the following table.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	-1.5	7.5	24.1	42.3	59.8	70.8	72.4	66.2	54.5	31.9	11.5	1.2	36.7
Average Min. Temperature (F)	-19.3	-14.7	-2.3	20.3	37.5	49.0	51.8	46.6	35.5	17.1	-5.0	-15.7	16.7
Average Windspeed (mph)	3.1	4.0	5.2	6.6	7.7	7.1	6.6	6.2	6.2	5.4	3.9	3.2	5.4

Pedro Dome RRS is a Formerly Used Defense Site (FUDS). The site was used by the U.S. Air Force as part of the White Alice Communications System. Pedro Dome was a combined tropo/micro station. Sixty-foot antennas faced Fort Yukon, 124 miles away and a second pair linked Bear Creek, 130 miles to the south. A seventy-five foot tower interconnected with Fairbanks Alaska Communications Site, 15 miles away, Harding Lake, Murphy Dome and Eielson Air Force Base. The current owner of the site is ALASCOM, Inc., d.b.a. AT&T Alascom, who currently maintains a nonresident work force of one to two employees.

Existing site features include the foundations of the former dormitory and equipment building, and former tropospheric scatter antenna foundations. Three apparently unused buildings include an apparent shop, an office building, and a generator building constructed of poured concrete located west of the foundation of the dormitory and equipment building. In addition, two fenced communications facilities are presently operating at the site, one operated by the Federal Aviation Administration and the other by AT&T Alascom (See Figure 4).

The focus of the remedial actions at the former Pedro Dome RRS was a former water tank and pumphouse. The pumphouse and water tank were located near the former dormitory/equipment building. Four electric heaters were utilized to prevent the water tank from freezing during the winter. The heaters were each filled with 7 to 8 gallons of PCB-containing oil (See figures 6 and 14). It is assumed that periodic maintenance of the heaters or replacement of the oil resulted in soil contamination at each of the four heater locations. Site operation and maintenance activities apparently spread this contaminated soil around the immediate area.

The geology and soil conditions on Pedro Dome are consistent except where clean gravels were backfilled for foundations of improvements. Two to three feet of silty gravelly sand to silty sandy gravel is found in the upper 2 to 3 feet. From the surface to a depth of 5 feet, large boulders (2 to 4 feet in maximum dimension) are found that are surrounded by tan silt. The tan silt completely surrounds these boulders and makes up approximately 50% of the material found to this depth. From 5 feet to 7 feet weathered rock is found. This rock is classified as quartz-dacite. The predominant mineral in the quartz-dacite bedrock of Pedro Dome is fine-grained (aphanitic) crystalline quartz, which comprises at least 75% of the rock. The bluish-gray color is given by the minerals biotite, hornblende, magnetite, and tetanite. These minerals plus the feldspars make up the remaining 25%. These rocks have been mapped by the USGS (Bulletin 872) in the general classification of Mesozoic Granite Rocks. In the weathered rock, small fractures are found that are filled with silt. These fractures vary in size from 1/8 inch to ¼ inch in width. From 7 to 8 feet dense, sound, quartz-dacite rock is found. The rock has lost all evidence of weathering at this depth, which attests to its soundness, and absence of fracturing and open jointing. The rock is extremely hard and resistant to drilling (USACE 1956, USACE 1963).

The nearest water supply wells to the Pedro Dome site are at the Cleary Summit. There is anecdotal information that only some of these residences have wells, and that depth to groundwater is about 150 to 200 feet. The water supply for the formerly operated Pedro Dome RRS facility was provided by pumping water from nearby Skoogy Creek (about 4,100 feet away) at a location adjacent to the Steese Highway (S&W 1997). According to the Alaska Department of Natural Resources (ADNR 1995), the nearest wells to the site are as follows.

Description	Approx. Dist & Dir
Cleary Summit Sub L4 BC	1.5 m NE
Discovery Sub L2	3.5 m SSW
Discovery Sub L3	3.5 m SSW
Discovery Sub L4	4 m SSW
Section 28 Lots	4 m SSW
TL 2805	4 m SSW
TL 2803	4 m SSW
FBKS/STEESE HWY MI 10	4 m S
FBKS/STEESE HWY MI 27	5 m NNE
STEESE HWY MI 14	2.5 SSW

2.2 History

Pedro Dome Tract "A" (main cantonment area of 25 acres) was acquired from the U.S. Department of the Interior (USDOI) on 28 July 1958 by Public Land Order No. 1697. Tract "B" (water supply area on Skoogy Creek, 5.79 acres) was acquired from the USDOI on 15 May 1959 by notation on Public Land Records. Tract "101P" (water line right-of-way, 0.03 acres) was acquired as a Use Permit from the State of Alaska (USACE 1959) (See Figure 3).

The station was constructed in 1957 and opened on 6 January 1958. It was incorporated into the Ballistic Missile Early Warning System (BMEWS) in the mid-60s. The equipment and power building was 9,120 SF and the attached 16-person dormitory was 5,200 SF. Also on site were a warehouse, water pumphouse, auto maintenance building, fire pump station and POL storage with a 470-barrel capacity (USACE 1988).

Tracts A and B were conveyed to ALASCOM, Inc., by deed dated 1 May 1984. Tract 101P Use Permit was terminated 31 OCT 1986 (USACE 1959).

New Horizons Construction Co. (under contract to ALASCOM) completed an investigation of the soil around the water tank. Results included PCB contamination up to 59,363 mg/kg. A site investigation by the USACE-POA in 1989 confirmed the sampling done by New Horizons.

A chronology of significant events is given in Table 1.

3. Remedial Planning Activities

3.1 General

In 1989, the USACE-POA identified the Pedro Dome RRS as a Formerly Used Defense Site (FUDS) eligible for cleanup under DERP-FUDS. A combination of investigations and removal actions were utilized in order to quickly remove the worst of the contamination and remediate the site in a cost effective manner.

USACE and USACE contractor, Ecology & Environment conducted an initial site visit on September 15, 1989. This was followed by an Inventory Project Report (INPR) in 1989 and authorization from Headquarters USACE for remedial design and remedial action (USACE 1989a). The Environmental Assessment, Finding of No Significant Impact (FONSI) and Right-of-Entry were competed in 1991. USACE-POA completed the removal action design and contract was awarded to Oil Spill Consultants (OSC) in 1991.

The first removal action excavated the heaviest PCB-contaminated soil but the contract capacity was exceeded and some contaminated soil remained. In 1992, ALASCOM sent a letter to USACE requesting additional cleanup at the Pedro Dome site (ALASCOM 1992). Specific mention is made of an abandoned military fuel tank and abandoned military barrels. The INPR was revised in 1992 to include the drums and any associated contaminated soil (USACE 1992b). Authorization for remedial design and remedial action was received in 1993 (USACE 1993a). The fuel tank was beneficially used by others since transfer from DOD. Therefore, the fuel tank was ineligible for cleanup under FUDS. The drums and any contaminated soil were removed by others prior to any USACE action. One of the requirements of the FUDS program is that facilities cannot have been beneficially used by others since the DOD transfer. At the Pedro Dome site, the only facility that was not beneficially used was the water pumphouse and associated pumphouse and piping. The second removal action was designed by USACE-POA and included the removal of the water tank, pumphouse and PCB-contaminated soil. This removal action was a continuation of the first and was covered by the existing Environmental Assessment and FONSI.

Work during the first two removal actions revealed that the PCB-contamination had been spread throughout the immediate area due to operations and maintenance at the site. A rapid assessment (streamlined risk assessment) was conducted by USACE in 1995 (USACE 1995b). Potential remedial alternatives included no action (due to low risk), capping site, or removal. However, the assessment indicated that additional investigation was required due to the extent of contamination. USACE contracted with Shannon & Wilson, Inc. (S&W) to conduct additional investigations. S&W dug test pits and took samples (S&W 1997). In 1997, USACE updated the Environmental Assessment and FONSI and performed an Engineering Evaluation and Cost Analysis (EECA). The EECA recommended cleanup to 10 mg/kg (See paragraph "Establishment of Remedial Action Objectives" for discussion of Toxic Substance Control Act (TSCA) and the Alaska Department of Environmental Conservation (ADEC) regulations.). USACE update the Right-of-Entry in 1998. In 1999, Linder General & Environmental Contractors, under contract to USACE performed the final removal action.

3.2 Significant Chemical Data

Data collected from the investigations and removal actions (1987 – 1999) conducted at the site, identified contamination at the main cantonment area near the water storage tank and pumphouse.

Sampling occurred in 1987 (Figure 16), 1991, 1993 (Figure 17), 1996 (Figure 18) and 1999 (Figure 19). Table 2 shows the sampling results from pre-remedial sampling. These soils have been removed by one of the three removal actions at the site. Table 3 shows post-remedial action sampling for soil remaining on site after the last removal action in 1999. Due to inconsistencies in the sketch from the 1987 sampling, these results are not shown in Tables 2 or 3.

3.3 Establishment of Remedial Action Objectives

The objective of the DERP-FUDS Program is to reduce, in a timely, cost-effective manner, the risk to human health and safety and the environment resulting from past DOD activities (USACE 1999). The Remedial Action Objectives (RAO's) established for this project were to protect human health and the environment by:

- Treatment or disposal of PCB-contaminated soils.
- Removal of water tank, pumphouse, and pipelines incidental to the removal of the contaminated soil;

The objectives were consistent with the work authorized by the Department of Defense. The work performed complied with appropriate state and federal regulations.

Since Pedro Dome is near Fairbanks, the utilization of successive removal actions to remove the PCB-contaminated soil and concurrently characterize the site was implemented. After the first two removal actions, a cleanup level of 25 mg/kg was initially proposed. However, after consultation with ADEC, the cleanup goal was lowered to 10 mg/kg. See paragraph "Risk Evaluation" for a discussion of ADEC regulations.

This cleanup level was consistent with the TSCA specified levels. TSCA sets cleanup levels for post 1978 spills. For cleanup in non-restricted areas, TSCA specifies "the spill will be decontaminated to 10 ppm PCBs by weight provided that soil is excavated to a minimum depth of 10 inches. The excavated soil will be replaced with clean soil, i.e., containing less than 1 ppm PCB, and the spill site will be restored (e.g. replacement of turf)." Cleanup policy for restricted areas other than outdoor electrical substations states "soil contaminated by the spill will be cleaned to 25 ppm PCBs by weight." An option to these cleanup levels is a PCB risk-based closure.

TSCA does not establish cleanup levels for older (pre 1978) spills. This is stated in the scope of TSCA subpart G. The scope goes on to say that old spills (i.e. pre 1987) require a site-by-site evaluation and cleanup coordinated with EPA. Since it is unknown when the actual spills at Pedro Dome occurred, it has to be assumed that the spills occurred both before and after 1978. Therefore, the post 1978 regulations would apply. EPA was involved with the actions and planning for the Pedro Dome RRS removal actions (EPA 1991, EPA 1997, EPA 2001a, EPA 2001b).

4. Remedial Activities

In 1991, under contract to USACE-POA, OSC excavated, removed and disposed of about 146 CYs of PCB-contaminated soil. Disposal was at the EnviroSafe Services Environmental Protection Agency (EPA) permitted landfill in Grandview, Idaho. This soil was from the immediate vicinity of the four heater wells in the water tank. The heater wells in the water storage tank were also removed and disposed.

In 1993, the second removal action was also conducted by OSC under contract to USACE-POA. This removal action demolished the water tank and pumphouse. Steel from the water tank demolition was recycled. Demolition debris from the water tank and pump house was landfilled at the Fairbanks North Star Borough (FNSB) state permitted landfill in Fairbanks, Alaska. Approximately 600 pounds of ACM asphalt shingles from the water tank was removed and disposed of at the FNSB landfill. About 340 CYs of PCB-contaminated soil was excavated and disposed at the EnviroSafe Services EPA permitted landfill in Grandview, Idaho. Contract capacity was reached prior to removal of all contaminated soil. The excavation was lined with plastic sheeting and backfilled with clean soil (See Figures 7, 8, and 9).

In 1999, under contract to USACE-POA, Linder General & Environmental Contractors conducted the final removal action. Linder removed the clean soil above the liner, stockpiled it, tested it, and after verifying all contamination was below 10 mg/kg, used it for backfill. About 300 CYs of PCB-contaminated soil was excavated and disposed of at the EnviroSafe Services EPA permitted landfill in Grandview, Idaho. This soil was excavated from the area of the former water tank and pumphouse, and from an area near the drainpipe to the water tank (Figure 19). Approximately 47 linear feet of water line with ACM insulation was removed and disposed of at the FNSB landfill. All backfilled soil tested less than 10 mg/kg. The cleaner soil was backfilled near the surface, while soil testing close to (but below) the 10-mg/kg limit was backfilled deeper. To further reduce exposure, the top inch or so of the area was bladed into the excavation. Prior to backfilling, the excavations were lined with plastic sheeting (See Figures 10, 11, 12, and 13).

On 11 June 2001, ADEC, USACE, and AT&T Alascom visited the Pedro Dome Site and later met in Fairbanks to discuss the Pedro Dome closeout. Five alternatives were discussed. Final decisions were postponed until additional information was researched.

5. Community Relations Activities

Residents near the site, as well as community members of Fairbanks, Alaska had the opportunity to participate in the National Environmental Policy Act (NEPA) public input process. Through that process, findings of no significant impact were made in May 1991 and October 1997 (USACE 1991a, USACE 1997c). Notice on the final removal action was published in the Fairbanks Daily News-Miner in October 1997. Public notices were also posted at the Chatnika Lodge, Fox General Store, Turtle Club, FE Company, Fox Roadhouse, and Gold Dredge No. 8 in July 1996.

6. Demonstration of QA/QC from Cleanup Activities

Performance Standards for this project were defined in the contract documents in the form of Special Contract Requirements, Contract Clauses, and Technical Specifications that stated the specific tasks and activities, which the contractor was required to accomplish at the site.

The contract required the contractor to submit project plans, which included the Work Plan, Sampling Plan, Disposal Plan, and Safety Plan. These plans were reviewed for compliance with regulatory requirements, quality control, and quality assurance procedures and protocols. Chemical quality control requirements were defined in the contract specifications. Accordingly, only EPA approved analytical methods were used. All data quality objectives were achieved and the quality of the chemical data supports the decisions that were made at the site. The QA/QC program utilized throughout the USACE remedial investigations and actions was sufficiently rigorous and compliance was achieved for work conducted at the site.

7. Risk Evaluation

ADEC cleanup regulations went through a major transition during the late 1990s and culminated with the publication of risk-based cleanup levels in 1999 under 18 AAC 75. These regulations specify cleanup levels for about 100 chemicals. The cleanup level depends on the applicable exposure pathway (incidental ingestion of soil, inhalation of vapors, and migration to groundwater and subsequent ingestion). PCBs are included in this list with a level of 10 mg/kg for ingestion, inhalation, and migration to groundwater. However, reference is made to a footnote, which reads as follows.

> For residential land use, the cleanup level for PCBs in surface soil is 1 mg/kg; for commercial or industrial land use, the cleanup level for PCBs in surface soils is 10 mg/kg and for PCBs in subsurface soil is 25 mg/kg; a responsible person may also propose an alternative cleanup level through an approved site-specific risk assessment, conducted according to the *Risk Assessment Procedures Manual*, adopted by reference at 18 AAC 75.340.

Although the new ADEC regulations are risk-based for the majority of chemicals, this is not the case for PCBs. The 18 AAC 75 PCB levels are based on TSCA requirements for new (post 1987) spills. ADEC is currently reevaluating the PCB regulatory cleanup level.

All soil tests for soils remaining on site at the Pedro Dome site have results below 10 mg/kg. This is below the ADEC regulations for industrial areas. ADEC (ADEC 1997) and ALASCOM (S&W 1997) both state that the Pedro Dome site is currently an industrial / commercial site. Indications from ALASCOM are that the future use will probably not change. Since there is no resident work force, these industrial cleanup levels are very conservative since they are based on workers present on site 250 days per year. Calculation of the 95% Upper Confidence Level returns a Reasonable Maximum Exposure (RME) concentration of 2.8 mg/kg (See Appendix A).

Using the RME of 2.8 mg/kg, the on-site risk using the residential scenario is 7×10^{-6} and the hazard index is 1. In Appendix B the calculated risk is 6.93E-6 and calculated hazard index is 1.4. EPA procedure is to report the risk and hazard to one significant figure (EPA 1989, pp. 8-7, 8-8, and 8-12). While this may appear that the actual hazard is 40% higher than reported, however this is not the case. The hazard index, or quotient is described as follows.

> "The noncancer hazard quotient assumes that there is a level of exposure (i.e., RfD) below which it is unlikely for even sensitive populations to experience adverse health effects. If the exposure level (E) exceeds this threshold (i.e., if [HQ =] E/RfD exceeds unity), there may be concern for potential noncancer effects. As a rule, the greater the value of [HI] above unity, the greater the level of concern. Be sure, however, not to interpret ratios of [HI] as statistical probabilities; a ratio of 0.001 does not mean that there is a one in one thousand chance of the effect occurring. Further, it is important to emphasize that the level of concern does not increase linearly as the RfD is approached or exceeded because RfDs do not have equal accuracy or precision and are not based on the same severity of toxic effects. Thus, the slopes of the dose-response curve in excess of the RfD can range widely depending on the substance." (EPA 1989, p. 8-11).

The risk of 7×10^{-6} and hazard index of 1 includes the incidental soil ingestion pathway and inhalation of volatiles pathway. The migration to groundwater pathway is not complete due to the depth of groundwater and the shallow, dense, sound bedrock on site.

The dermal contact pathway is not complete due to the generally cooler temperatures, which are not conducive to short sleeve shirts and pants. In addition, the majority of the remaining contamination on site is subsurface. The highest remaining contamination was from the bottom-of-hole samples and the stockpiled soils that were used as backfill. The average PCB test result at the surface is 0.78 mg/kg, while the average for the subsurface and backfilled stockpile soil is 1.26 mg/kg. In addition, the majority of the surface contamination was bladed into the excavation and covered with clean imported fill. The generally cooler temperatures at the site (albeit there are two months where the high temperatures are at 'room' temperature), and the higher contamination being subsurface make the pathway of dermal contact incomplete.

Particulate emissions are not a significant pathway since the risks due to inhalation of fugitive dusts are orders of magnitude less than the incidental ingestion pathway. In the EPA guidance (EPA 1996a), it states "Inhalation of fugitive dusts is a consideration for semivolatile organics and metals in surface soils. However, generic fugitive dust SSLs for semivolatile organics are several orders of magnitude higher than the corresponding generic ingestion SSLs. EPA believes that since the ingestion route should always be considered in screening decisions for surface soils, and ingestion SSLs appear to be adequately protective for inhalation exposures to fugitive dusts for organic compounds, the fugitive dust exposure route need not be routinely considered for organic chemicals in surface soils." While the risk evaluation completed herein is not a screening evaluation, the same conservative default parameters are used for exposure. Cowherd et al, states that field testing has shown that threshold wind speeds are in excess of 11 mph at the surface or 22 mph at 7 m above the surface. Average windspeed at Fairbanks is 5.4 mph annually. However, the high monthly average is 7.7 mph for May. Although wind erosion is related to peak gusts, Cowherd also states that particulate emission rates tend to decay rapidly (half life of a few minutes) during an erosion event. In addition, as noted above under the dermal contact discussion, the top layers of soil have less contamination present. Therefore, the pathway of particulate inhalation is not a completed pathway at the Pedro Dome site.

This risk of 7×10^{-6} is within the EPA target risk range of 10^{-4} to 10^{-6} and below the ADEC target risk of 10^{-5}. The hazard index of 1 is at the EPA and ADEC target.

8. Summary of Remedy

All the remedial action objectives for this site have been met. The remedial action objectives (RAO) established for this project to protect human health, and the remedial actions taken to meet these RAOs are summarized in this section.

1) Excavation and disposal of PCB-contaminated soil.
   - About 800 cubic yards of PCB-contaminated soil was removed from the excavations in the vicinity for the former water tank, pumphouse, and drain line (swale). The PCB-contaminated soil was transported for disposal at the EnviroSafe Services Environmental Protection Agency (EPA) permitted landfill in Grandview, Idaho.
2) Removal of asbestos incidental to removal of contaminated soil.
   - Asbestos abatement was accomplished prior to demolition of the water tank and drain pipe.

The water table at the site is estimated to be over 150 to 200 feet deep (S&W 1997) and the bedrock is dense and sound (USACE 1956, USACE 1963). The closest residential area to the site is about six miles to the southwest. Due to these factors, the low levels (slightly over the 18 AAC 75 regulatory residential cleanup levels but below the industrial cleanup levels), risk range below the ADEC target risk (10^{-5}) for residential use, and the limited area of the contamination, this site is recommended for No Further Action.

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USACE 1997d, Public Notice: FONSI and EA circulated for public review, 6 OCT 1997.

USACE 1997e, Engineering Evaluation/Cost Analysis (EE/CA) for PCB Contamination at the Pedro Dome Radio Relay Station, Fox, Alaska," 29 OCT 1997.

USACE 1997f, FONSI signed.

USACE 1998, "Right-of-Entry for Environmental Assessment and Response," signed by owner: ALASCOM, INC., DBA AT&T Alascom, 29 JUN 1998.

USACE 1999, "Defense Environmental Restoration Program Formerly Used Defense Sites (DERP-FUDS) Program Manual, Official Interim Version, EC-200-3-7, 30 September 1999.

USACE 2001, " Pedro Dome Site Visit and Meeting 11 JUNE 2001," email dated 12 June 2001.

10. Tables

Table 1 - Chronology of Significant Events

Event	Event Date	Remarks
USACE Field Investigation	JAN 1956	Foundation investigation – two test pits dug by hand.
Pedro Dome RRS Activated	6 JAN 1958	
Land transfer from USDOI to DOD	1958 & 1959	PLO No. 1697 dated 28 JUL 1958 for Tract A, Note on Public Land Records 15 MAY 1959 for Tract B.
USACE Field Investigation	JUN 1963	Foundation Investigation – one auger hole.
Pedro Dome RRS becomes part of BMEWS	1965	Ballistic Missile Early Warning System
Site conveyed to ALASCOM	1 MAY 1984	
First PCB Investigation	1987	New Horizons Construction Co., under contract to ALASCOM took samples for 8 laboratory tests and 15 field tests.
USACE Site Visit	15 SEP 1989	Ecology & Environment Inc., and USACE personnel site visit.
HQ USACE authorizes RD and RA	25 NOV 1989	Remedial design and remedial action authorized as recommended in INPR.
Approved INPR	DEC 1989	Inventory Project Report approved by HQ USACE.
FDE signed.	21 MAY 1990	Findings and Determination of Eligibility signed by Headquarters USACE.
EA & FONSI	MAY 1991	Environmental Assessment and Finding of No Significant Impact.
ROE	17 MAY 1991	Right-of-Entry Agreement signed by ALASCOM.
Excavation completed for first Removal Action	3 OCT 1991	First removal action completed by Oil Spill Consultants (OSC) under contract to USACE.
Second Removal Action	1993	Second removal action completed by OSC under contract to USACE.
Right-of-Entry signed	13 JUN 1996	Second ROE
Remedial Investigation	Summer 1996	Investigation by Shannon & Wilson under contract to USACE.
Public Notice	3 JUL 1996	Notices posted at the Chatnika Lodge, Fox General Store, Turtle Club, FE Company, Fox Roadhouse, Gold Dredge No. 8.
Site Visit	16 JUL 1997	Site visit by USACE.
EA and FONSI	OCT 1997	Environmental Assessment and Finding of No Significant Impact issued.
Public Notice	5 OCT 1997	Notice published in the Fairbanks Daily News-Miner
EECA	10 DEC 1997	Engineering Evaluation and Cost Analysis and Finding of No Significant Effect signed.
ROE	29 JUN 1998	Right-of-Entry signed by ALASCOM.
Final Removal Action	1999	Final removal action conducted by Linder Construction Inc.

Table 2 – Pre-Remedial Action Data Presentation

ENVIRONMENTAL MEDIUM: ☐ **Surface Water** ☐ **Groundwater** ☐ **Air**
X **Soil** ☐ **Sediment** ☐ **Biota**

1. Compound of Potential Concern	2. units	3. Detection frequency	Concentrations above SQL 4.	55. Detection Limits	7. ADEC Table B Cleanup Level	8. Detection Frequency above Tbl. B
1993 Sampling by OSC						
PCB AROCLOR 1260	mg/kg	25 / 30	28, 62, 300, 120, 57, 430, 200, 3, 12, 14, 5, 140, 49, 48, 3, 4, 17, 3, ND, 50, 23, ND, 2, ND, ND, 0.08J, ND, 610, 17, 8		1 (residential) 10 (industrial) 25 (subsurf.)	23 / 30 17 / 30 12 / 30
1996 Sampling by S&W						
PCB AROCLOR 1260	mg/kg	45 / 52	28, 40, 0.19, 4.6, 34, 9.7, ND, 54, 25, 45, 11, 2.1, 21, 0.09, 29, 17, 4100, ND, 1800, 0.12, 48, 100, 72, 30, 21, 0.091, 3.7, ND, ND, 4.3, ND, ND, 4.8, 0.28, 0.14, 36, 0.29, 0.16, 2.8, 0.082, ND, 0.35, 0.074, 280, 0.13, ND, ND, 140, 30, 56, 0.1, 3.6		1 (residential) 10 (industrial) 25 (subsurf.)	29 / 52 22 / 52 16 / 52
1999 Sampling by USACE						
PCB AROCLOR 1260	mg/kg	2 / 2	0.0581, 13.5**		1 (residential) 10 (industrial) 25 (subsurf.)	1 / 2 1 / 2 0 / 2
1999 Sampling by Linder						
PCB AROCLOR 1260	mg/kg	20 / 20	0.769, 78.3, 10.9, 12.2, 26.1, 19.3, 269, 56.9, 193, 33.6, 208, 5.73, 5.99, 62.9, 48.8, <0.0352, 0.270, 2.15, 33.8, 14.0		1 (residential) 10 (industrial) 25 (subsurf.)	17 / 20 14 / 20 10 / 20
PCB Totals	mg/kg	92 / 104			1 (residential) 10 (industrial) 25 (subsurf.)	70 / 104 37 / 104 38 / 104

Results are from sampling events of 1993, 1996 and 1999. Cleanup values are from 18 AAC 75 Table B.
**With the exception of one sample, all positive sample results were for Aroclor 1260. One sample from the 1999 sampling returned 13.5 mg/kg of Aroclor 1242. Since the toxicity of Aroclor 1242 is the same as that of Aroclor 1260, this 13.5 mg/kg value is treated as Aroclor 1260.

Table 3 – Post-Remedial Action Data Presentation

ENVIRONMENTAL MEDIUM: ☐ **Surface Water** ☐ **Groundwater** ☐ **Air**
X Soil ☐ **Sediment** ☐ **Biota**

1. Compound of Potential Concern	2. units	3. Detection frequency	Concentrations above SQL 4.	55. Detection Limits	7. ADEC Table B Cleanup Level	8. Detection Frequency above Tbl. B
1996 Sampling by S&W						
PCB AROCLOR 1260	mg/kg	34 / 56	0.083, **1.2**, 0.22, **1.4**, **1.1**, **0.36**, 0.6, ND (0.056), **0.058**, ND (0.058), ND (0.054), **0.14**, 0.21, ND (0.056), **0.83**, 0.23, ND (0.055), **0.31**, ND (0.065), ND (0.058), 0.33, **ND (0.06)**, ND (0.058), ND (0.058), **0.22**, 0.17, 0.35, **0.8**, 0.12, ND (0.061), **0.29**, ND (0.06), ND (0.057), **ND (0.088)**, ND (0.060), ND (0.059), **0.25**, ND (0.060), ND (0.058), **ND (0.057)**, ND (0.060), ND (0.059), ND (0.067), **0.55**, **0.55**, **0.97**, **1.5**, **0.4**, **1.4**, **0.073**, **0.52**, **0.19**, **1.7**, **2.8**, **0.78**, **0.38**	0.054 – 0.088	1 (residential) 10 (industrial) 25 (subsurf.)	7 / 56 0 / 56 0 / 56
1999 Sampling by USACE						
PCB AROCLOR 1260	mg/kg	3 / 6	**0.147**, **ND (0.0410)**, **ND (0.0402)**, **ND (0.0397)**, **4.19**, **1.39**	0.0397 – 0.0410	1 (residential) 10 (industrial) 25 (subsurf.)	2 / 6 0 / 6 0 / 6
1999 Sampling by Linder						
PCB AROCLOR 1260	mg/kg	19 / 24	6.38, 2.08, 2.80, 5.84, ND (0.0322), 1.29, 6.52, 1.51, 7.16, ND (0.0376), **0.0707**, **0.138**, **3.28**, **0.585**, **0.230**, **2.29**, 4.68, 5.73, 5.83, 4.84, 1.01, ND (0.0363), ND (0.0361), ND (0.0409)	0.0322 – 0.0409	1 (residential) 10 (industrial) 25 (subsurf.)	15 / 24 0 / 24 0 / 24
DRO	mg/kg	1 / 1	13.2			
GRO	mg/kg	0 / 1	0	4.0		
PCB Totals	mg/kg	56 / 86			1 (residential) 10 (industrial) 25 (subsurf.)	24 / 86 0 / 86 0 / 86

Results are from sampling events of 1996 and 1999. These are the areas originally sampled and not remediate and 'bottom-of-hole' samples from those areas excavated. In other words, this is the contamination remaining on site. Cleanup values are from 18 AAC 75 Table B. PCB values **bolded** indicate surface soil samples. Averaging all PCB surface soil results yields 0.78 mg/kg. Averaging all remaining PCB values (bottom-of-hole and stockpiles soil backfilled) yields 1.26 mg/kg. NDs were averaged at one-half of the DL.

11. Figures and Photos

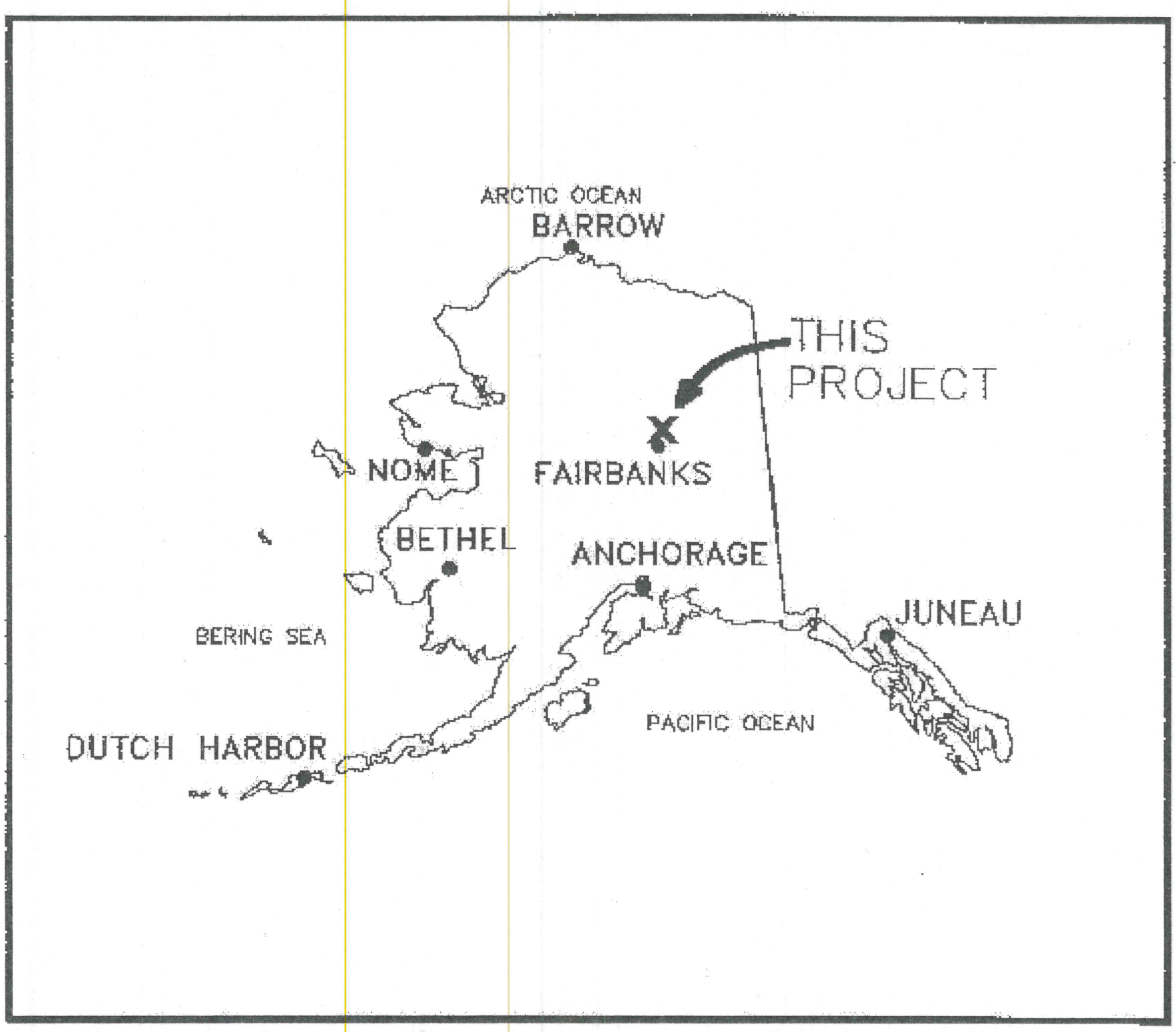


Figure 1 - Location Map

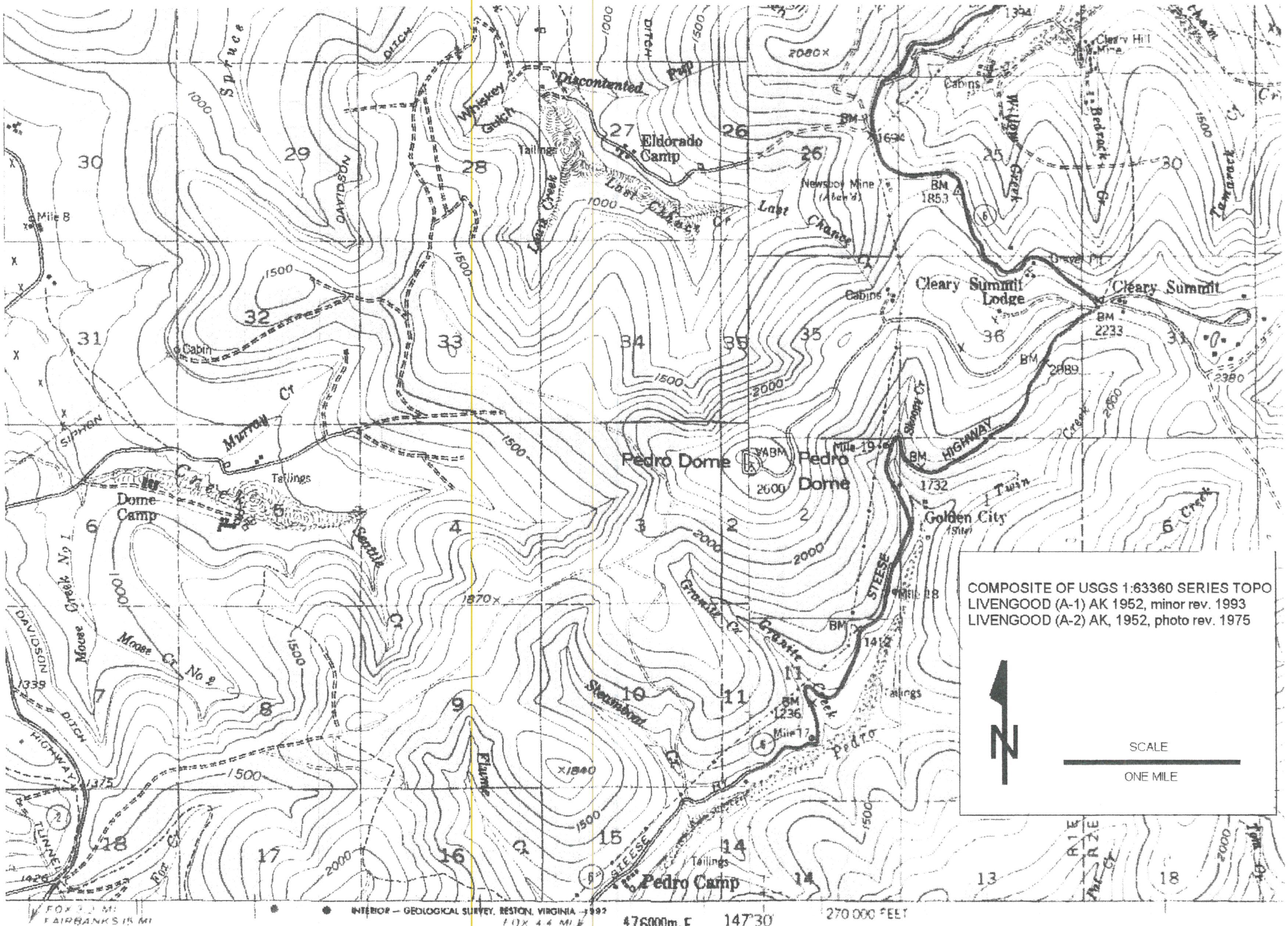


Figure 2 - Vicinity Map

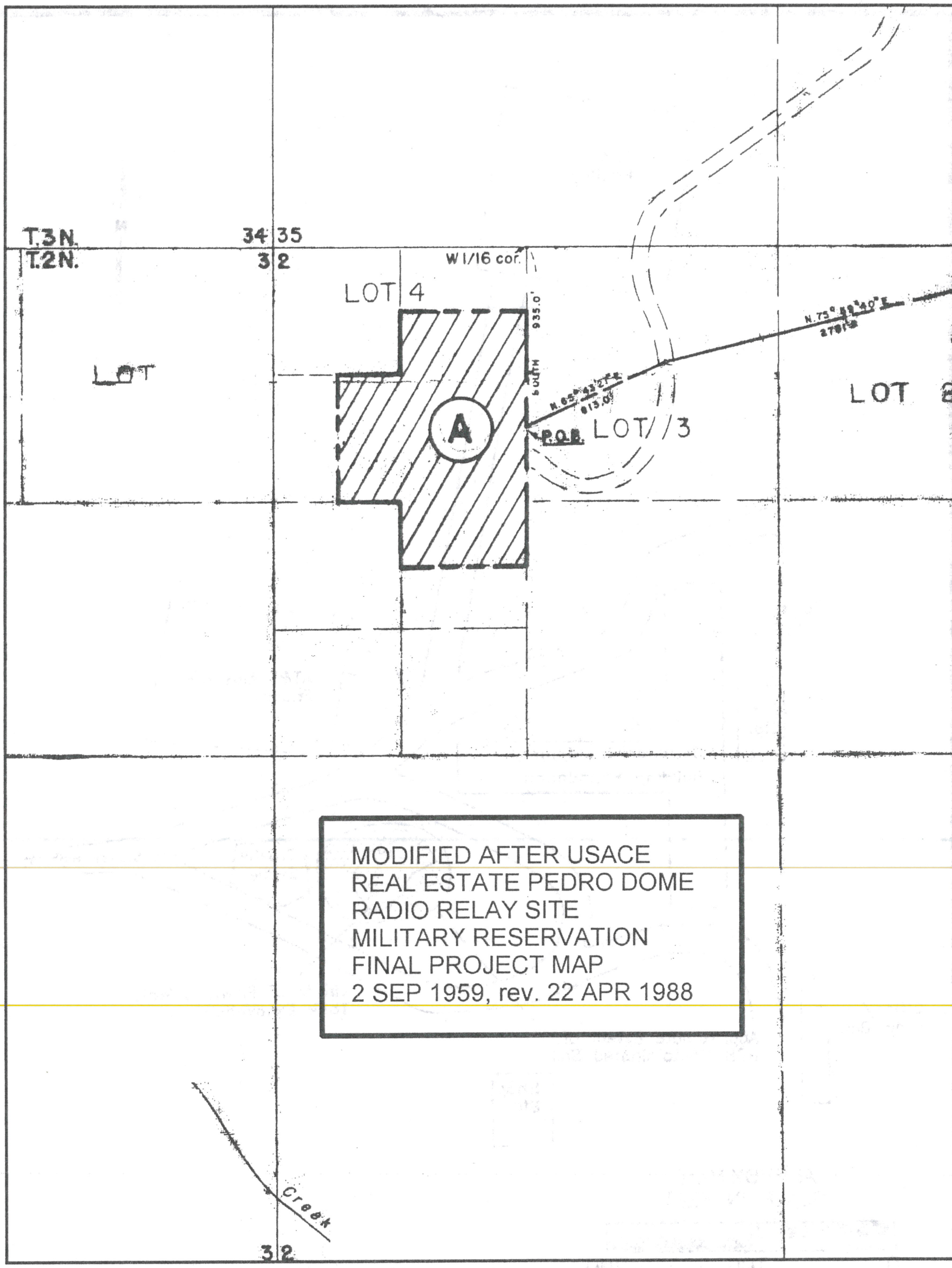
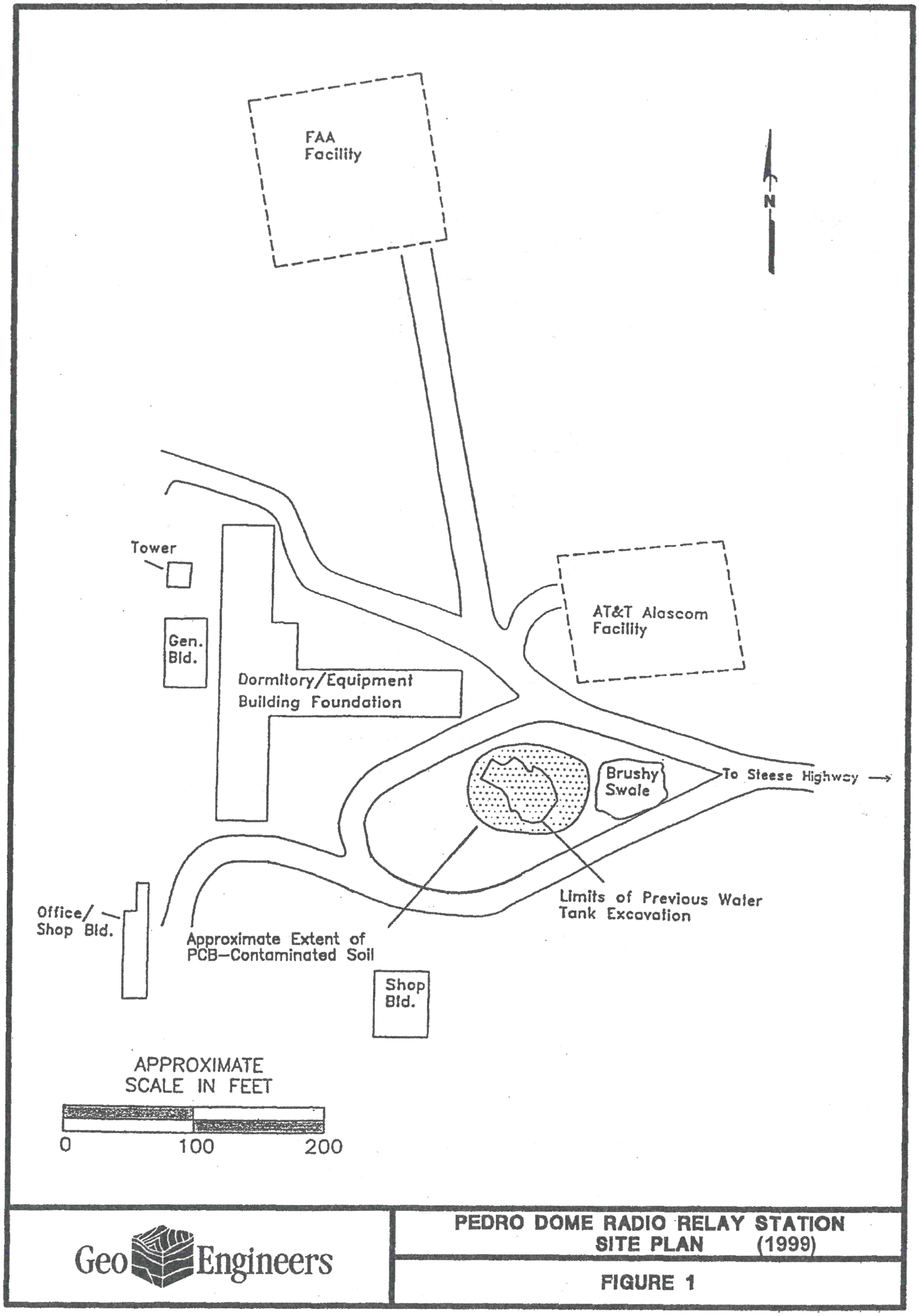


Figure 3 - Real Estate



Map

Figure 4 - Site Map

Figure 5 – Aerial Photograph - 1993

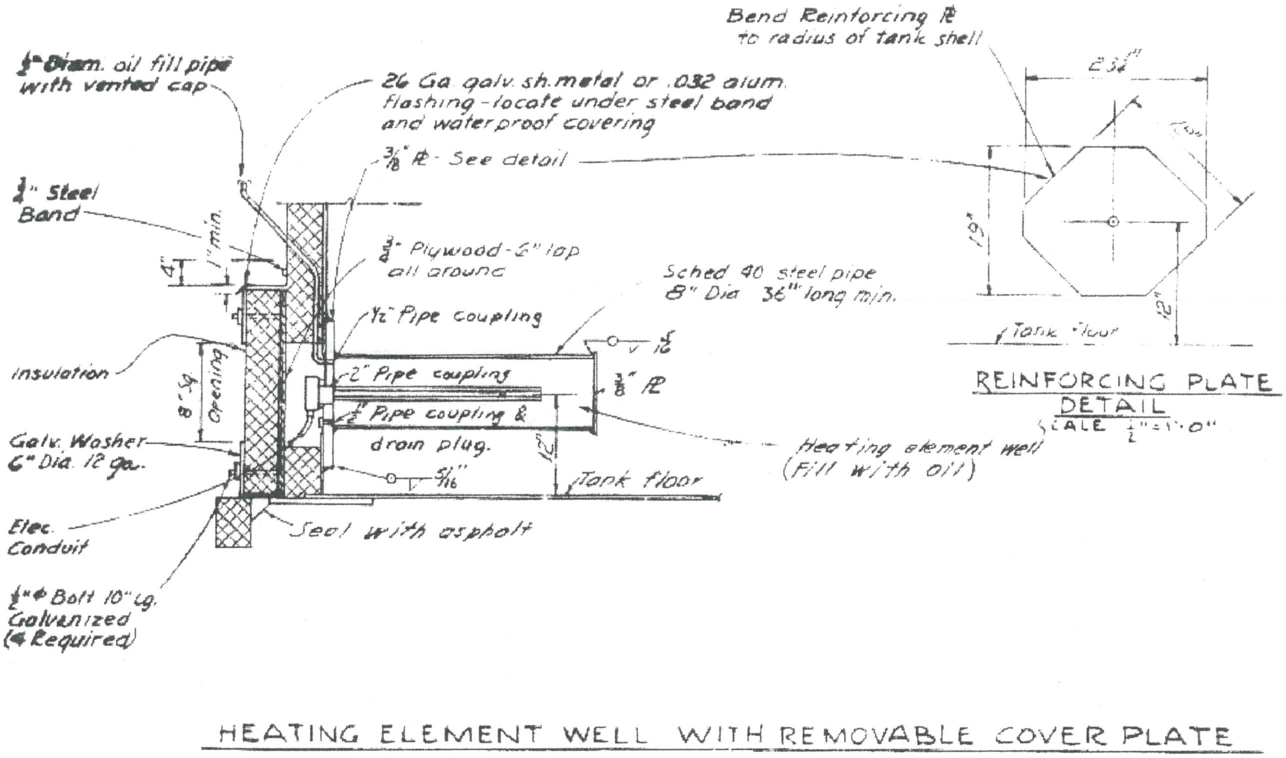
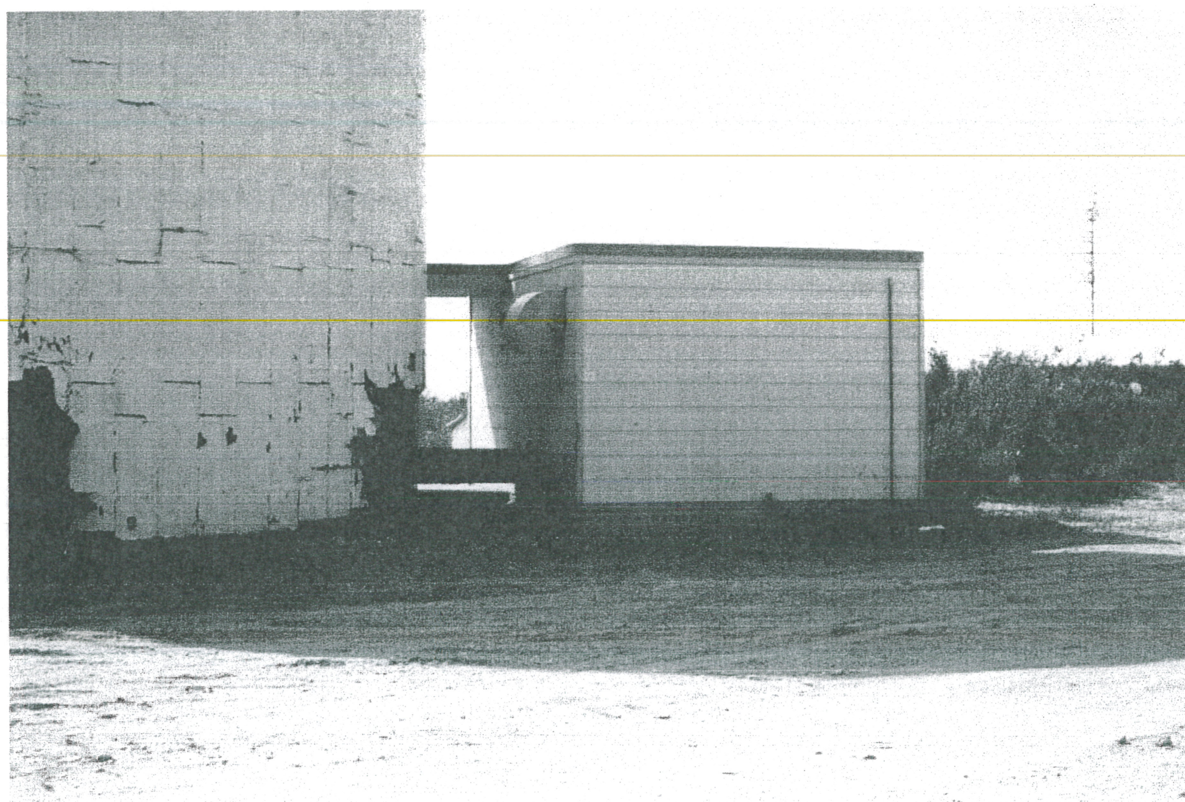
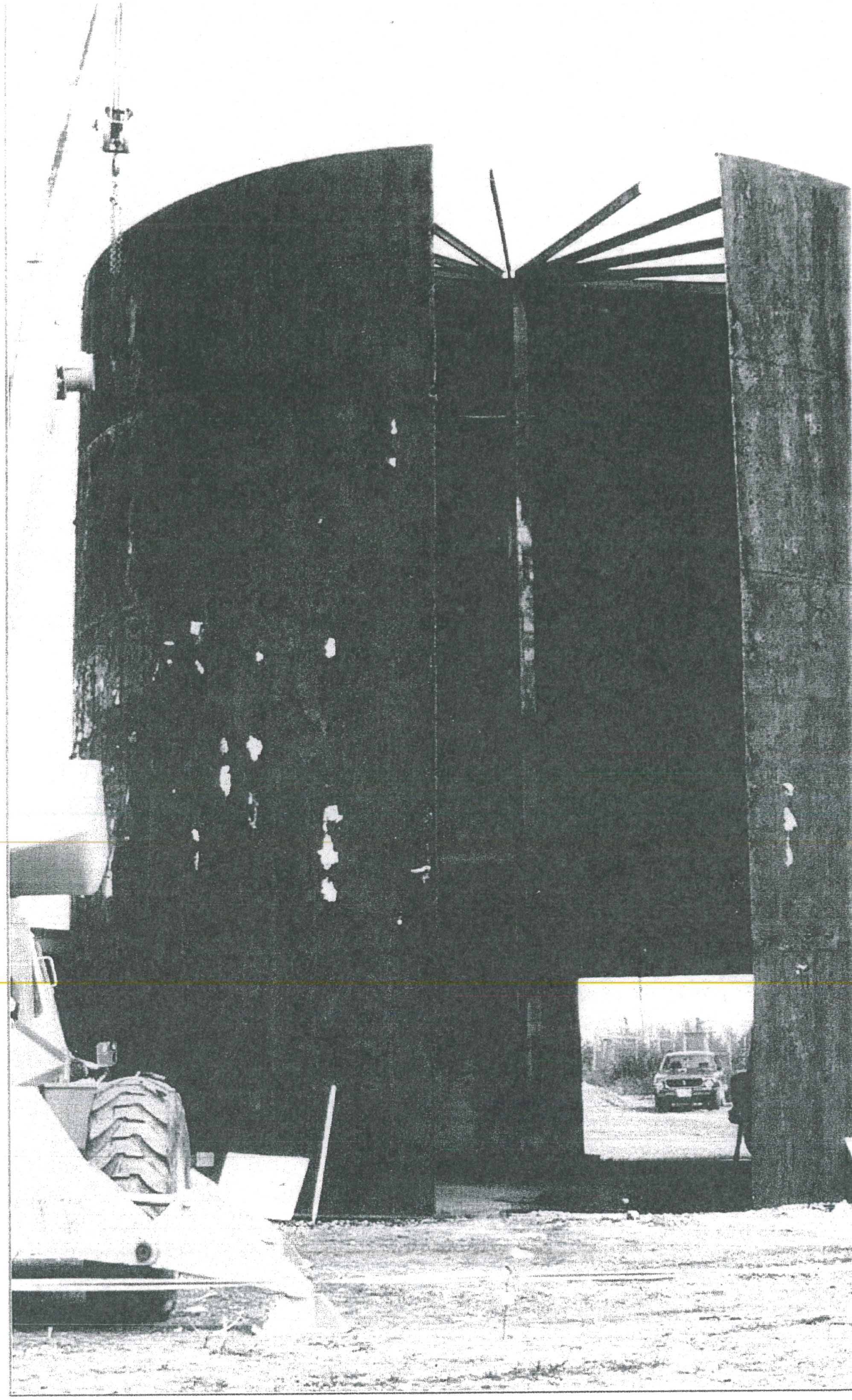


Figure 6 – Water Tank Heating Well



Pedro Dome, Tank & Pumphouse before demolition, July 15, 1993

Figure 7 – Tank and Pumphouse - July 15, 1993

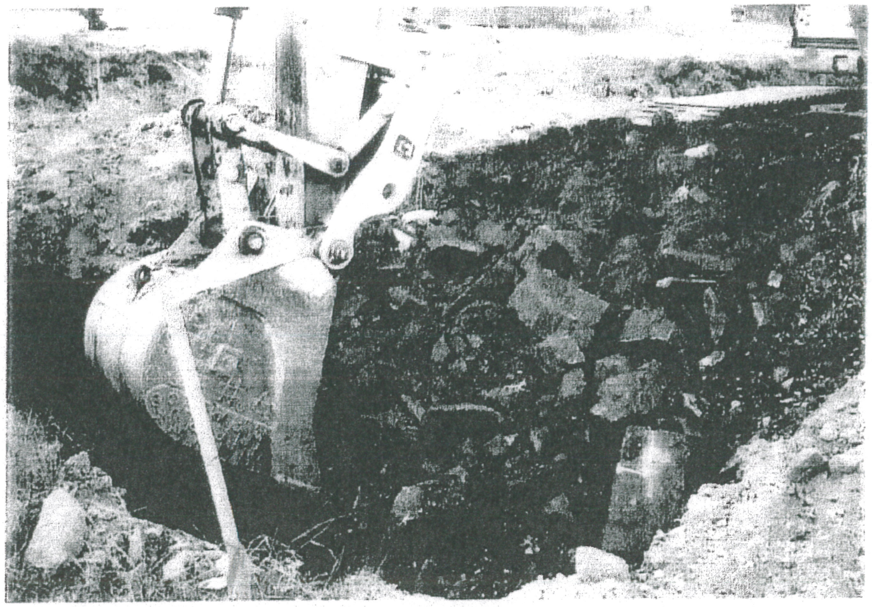


Pedro Dome, Tank demo, SEP, 1993

Figure 8 – Water Tank Demolition

Pedro Dome, Maximum Excavation at former water tank site. OCT 1993

Figure 9 - Maximum Excavation – 1993



22 Proj# 98-01-02 Date: 6/27/99
Project Name: Pedro Dome Location: Pedro Dome, AK
Facing Direction: South
Description: Soil conditions, lots of rock.

Contractor: Linder Construction Contract #: DACA85-98-D-0015
Roll# 5

Figure 10 - Excavation Near Bedrock

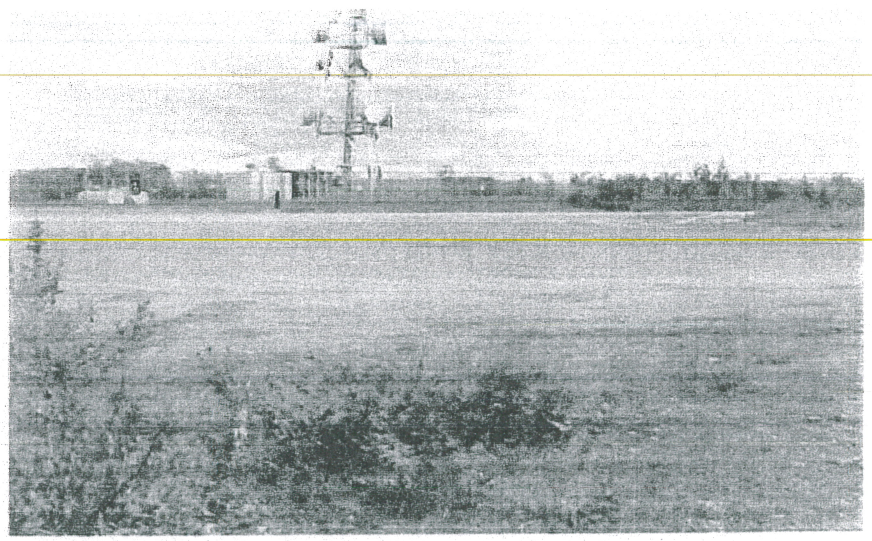
41 Proj# 98-01-02 Date: 8-26-99
Project Name: Pedro Dome Location: Pedro Dome, AK
Facing Direction: South
Description: Sample locations at swale excavation.

Contractor: Linder Construction Contract #: DACA85-98-D-0015
Roll# 3/9

Figure 11 - Excavation & Sample Locations at Swale

#	53	Proj#	98-01-02	Date:	8-27-99
Project Name:	Pedro Dome	Location:	Pedro Dome, AK		
Facing Direction:	West				
Description:	Install backfill material at pipe and swale excavation.				
Contractor:	Linder Construction	Contract #:	DACA85-98-D-0015		
Roll#	4/17				

Figure 12 - Linear & Backfill at Swale



#	55	Proj#	98-01-02	Date:	8-28-99
Project Name:	Pedro Dome	Location:	Pedro Dome, AK		
Facing Direction:	Northeast				
Description:	Excavation site after backfill.				
Contractor:	Linder Construction	Contract #:	DACA85-98-D-0015		
Roll#	5/3				

Figure 13 - Excavation Site After Backfill

Figure 14 - Former Water Tank Site, 11 June 2001

Figure 15 - Swale (Drainpipe) Area, 11 June 2001

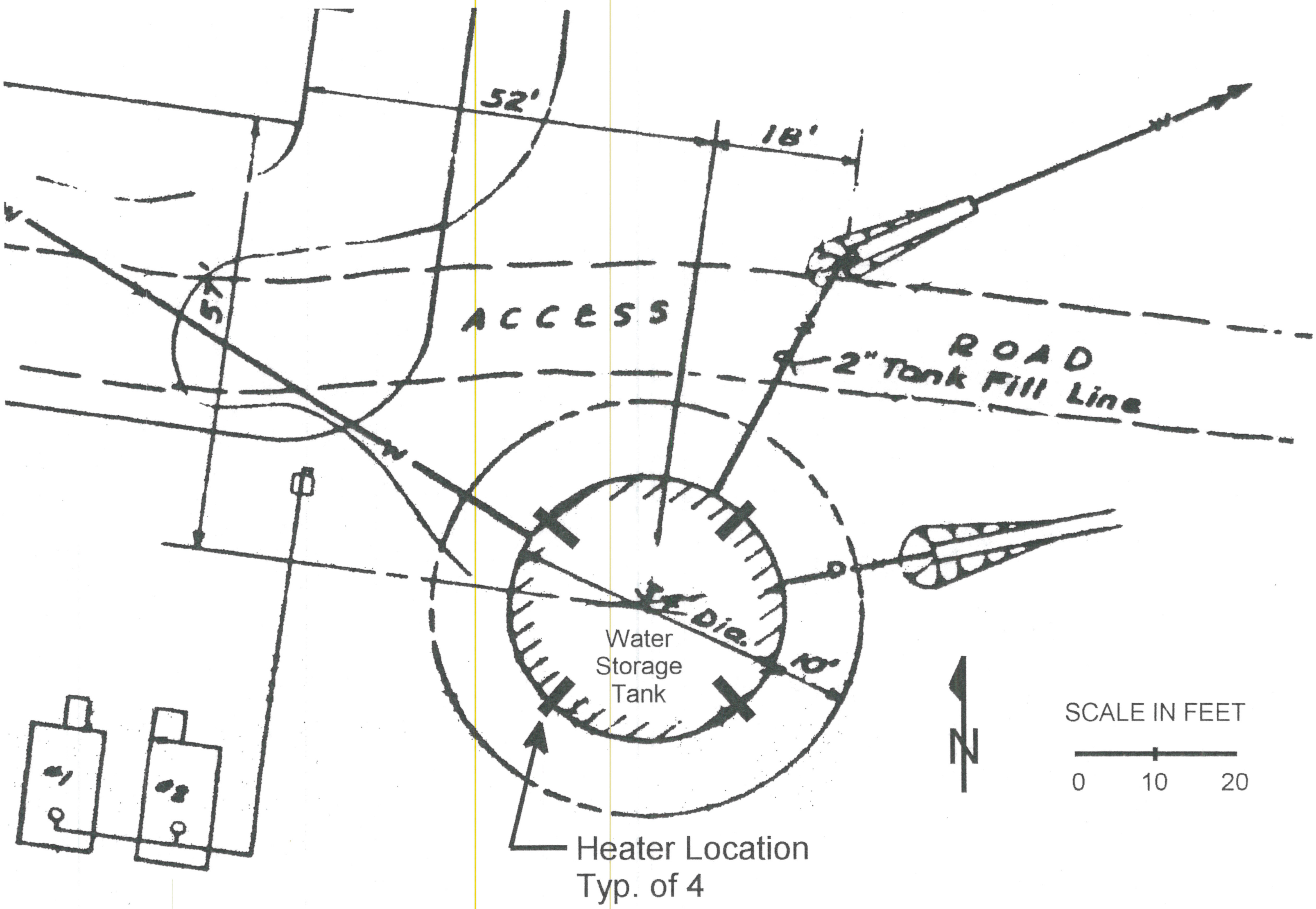
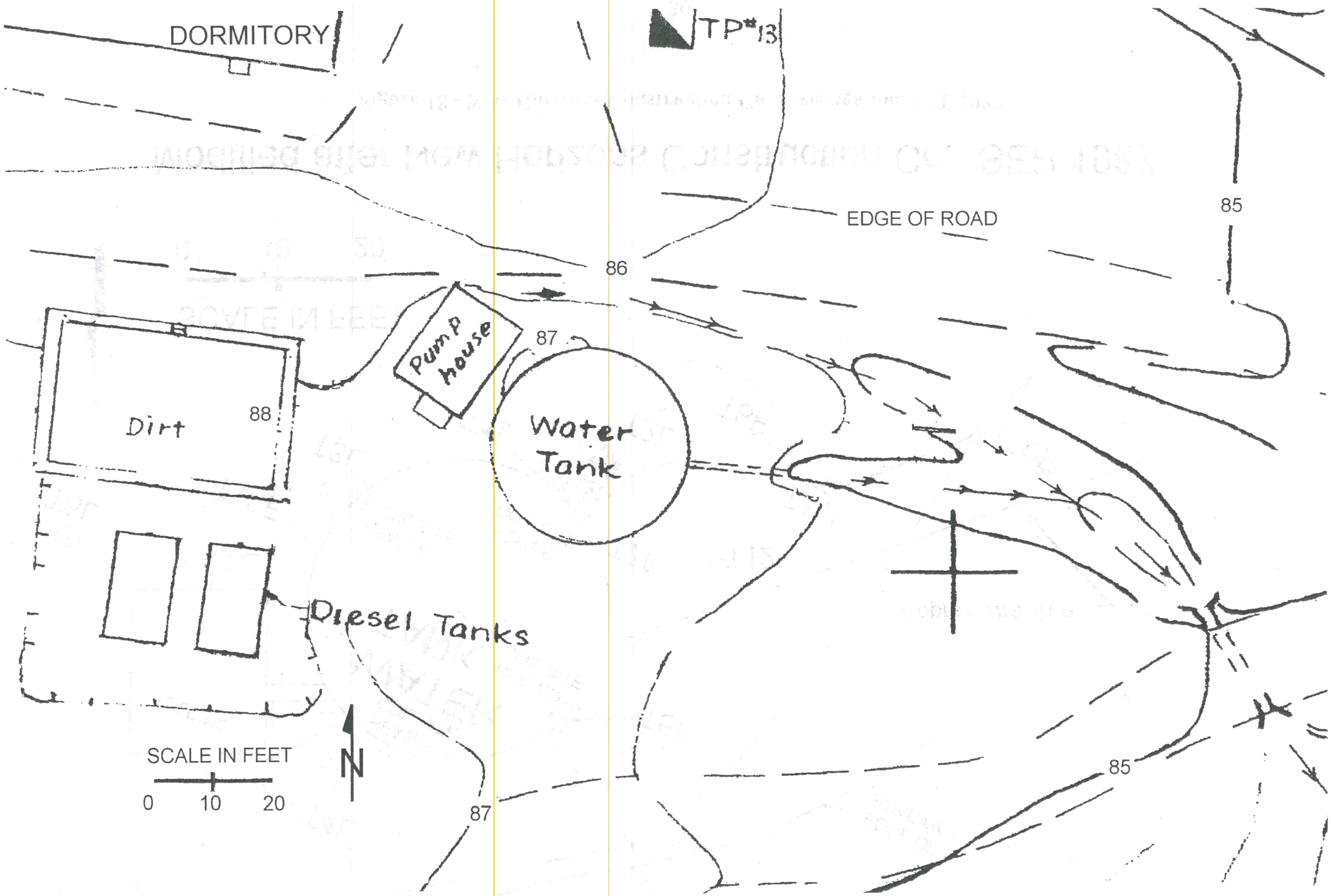
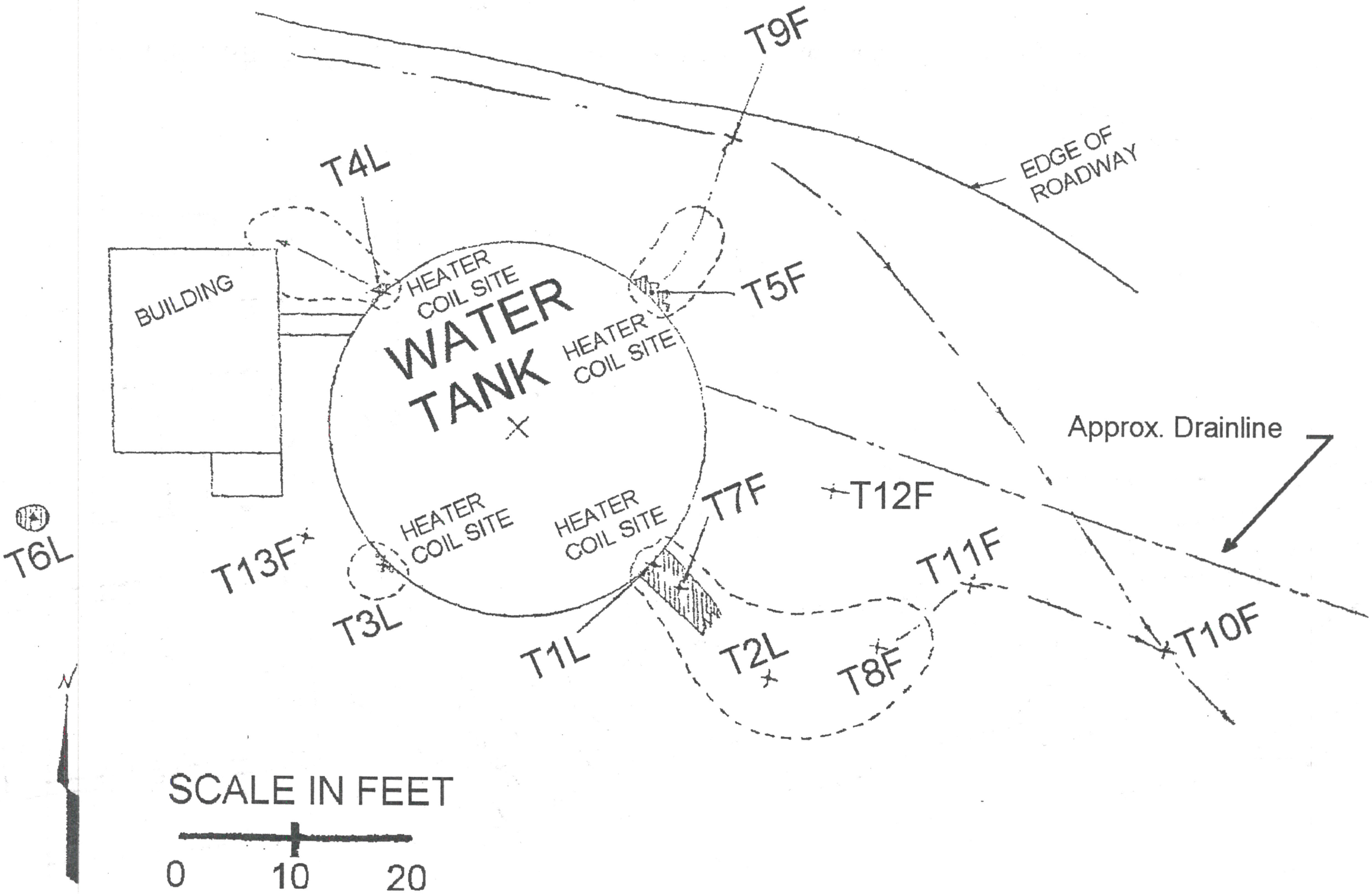


Figure 16 - USACE As-Built Site Plan, 30 OCT 1959



Modified after USACE, Pedro Dome, Alaska White Alice Topography, 21 SEP 1959, r. 6 JUN 1963

Figure 17 - USACE Topographic Survey, rev. 6 JUN 1963



Modified after New Horizons Construction Co., SEP 1987

Figure 18 - New Horizons Construction Co. Investigation, SEP 1987

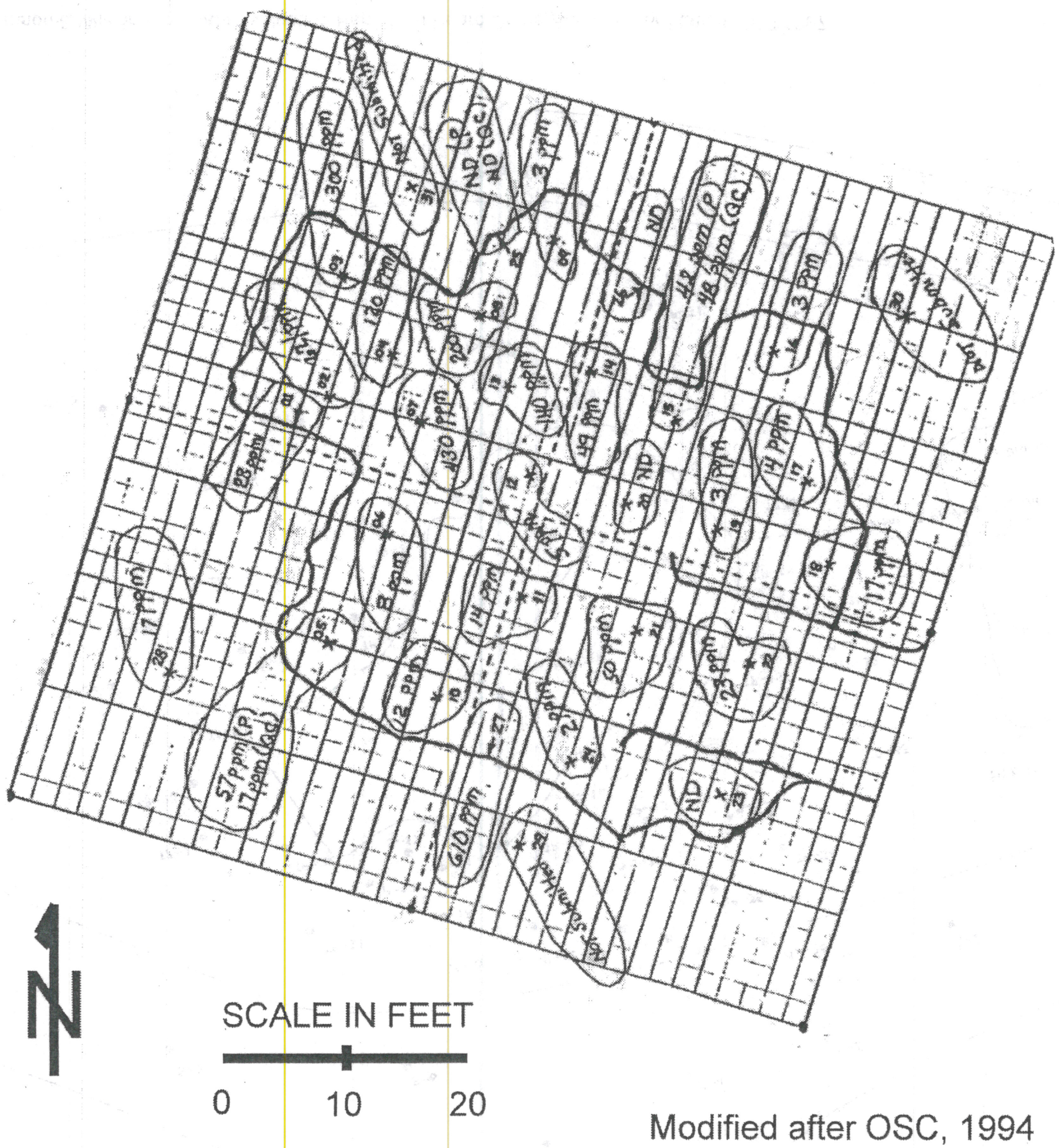
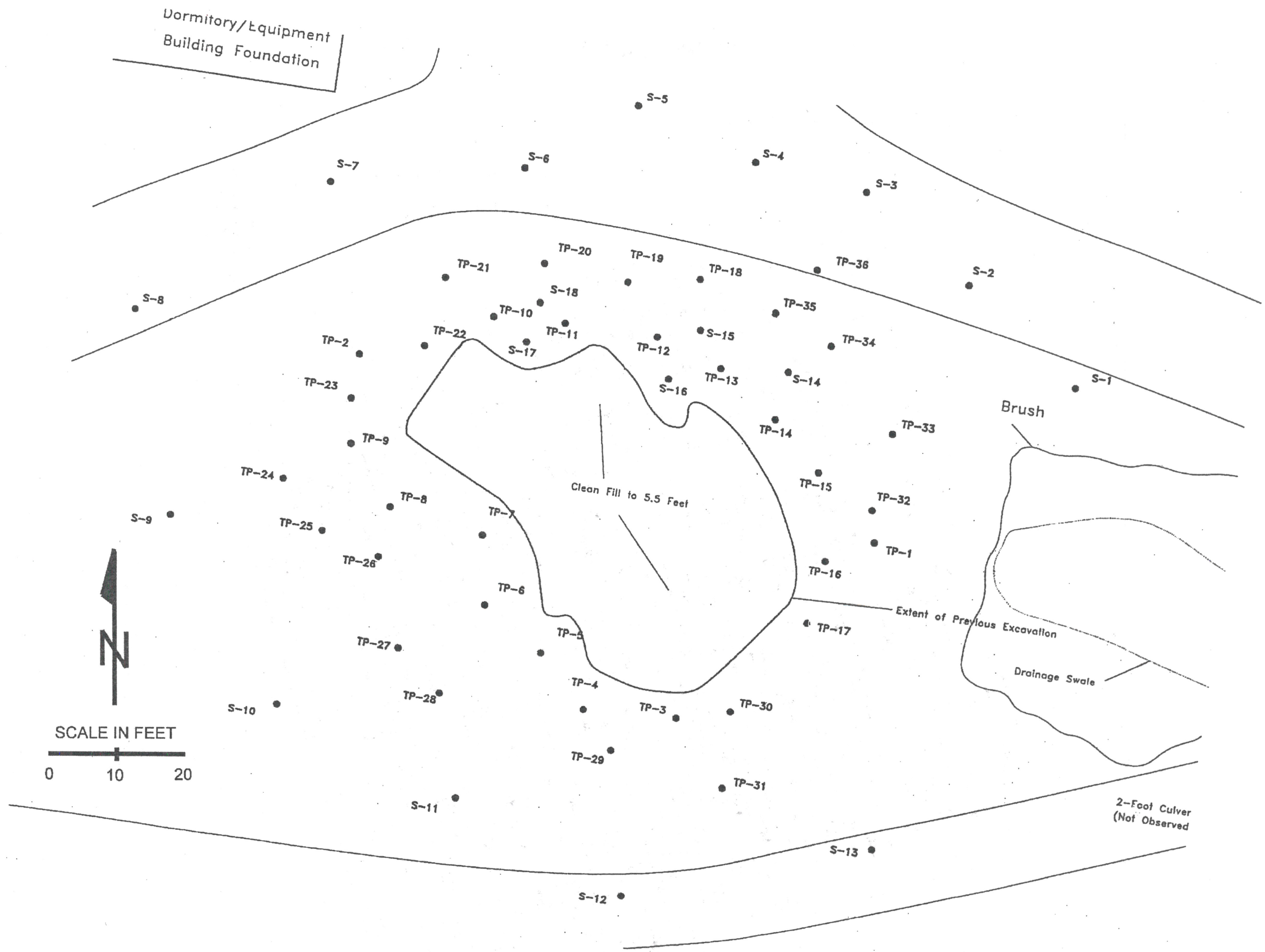


Figure 19 - Oil Spill 1993 Sampling Locations



Modified after Shannon & Wilson Inc., Data Evaluation Report, RI Pedro Dome Radio Relay Station, FEB 1997

Figure 20 - Shannon & Wilson 1996 Sampling Locations

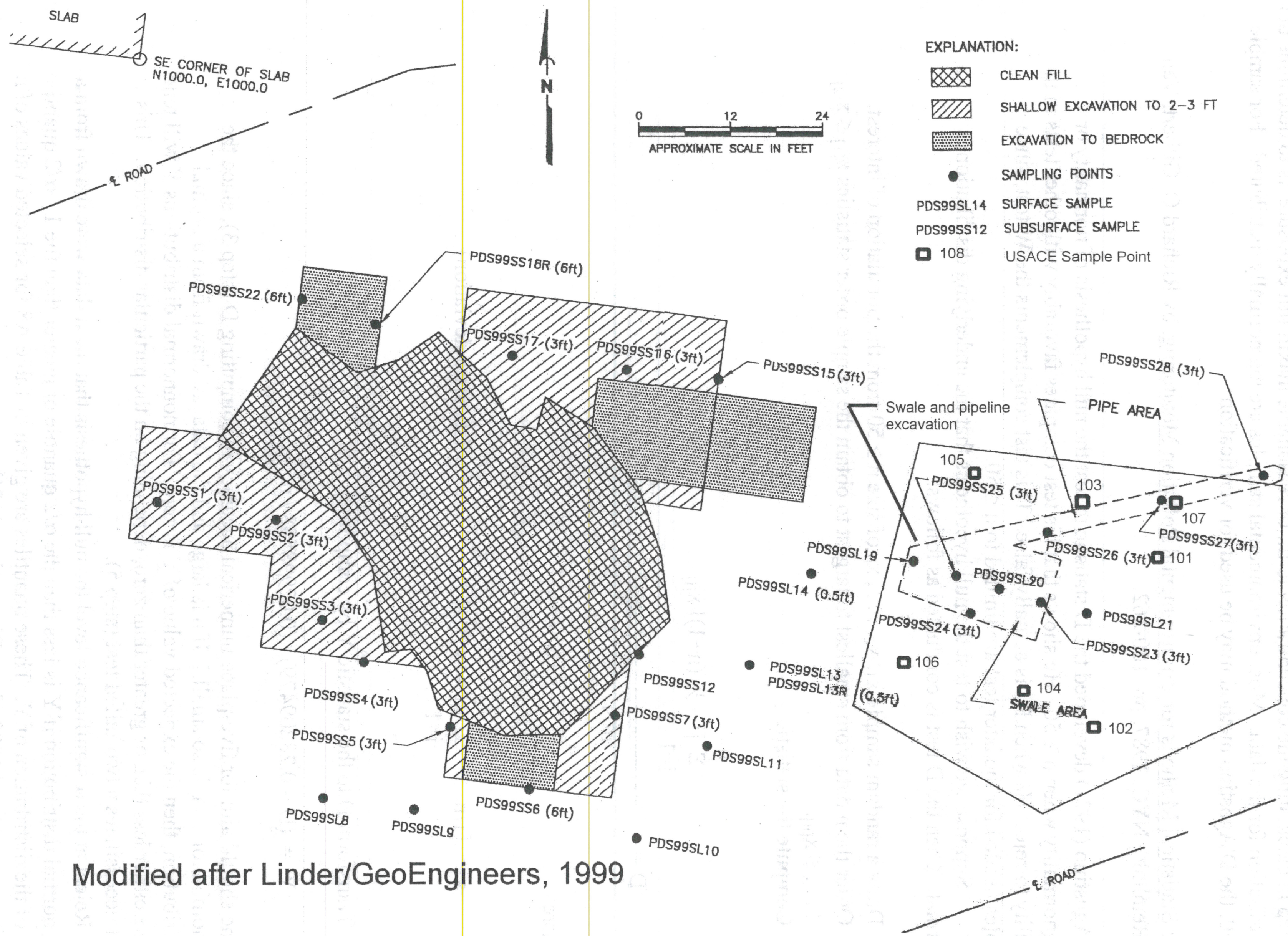


Figure 21 - Linder & USACE 1999 Sampling

APPENDIX A - CALCULATING THE CONCENTRATION TERM

The first step in calculating the concentration term, or reasonable maximum exposure, is to determine the type of distribution for the data. Most environmental samples are log normally distributed. For sample sets over 50, the D'Agostino method may be used for verification.

Reference: Statistical Methods for Environmental Pollution Monitoring, by Richard O. Gilbert, Van Nostrand Reinhold, NYC, 1987, pp. 160-162.

D'Agostino (1971) developed the D statistic to test the null hypothesis of normality or lognormality when $n \geq 50$. He shows that his test compares favorably with other tests in its ability to reject H_0 when H_0 is actually false. This test complements the W test, since tables needed for the later test are limited to $n \leq 50$.

Suppose we wish to test the null hypothesis that the underlying distribution is normal. Then the D test is conducted as follows:

1. Draw a random sample $x_1, x_2, \ldots, x_n$ of size $n \geq 50$ from the population of interest.
2. Order the n data from smallest to largest to obtain the sample order statistics $x_{[1]} \leq x_{[2]} \leq \ldots \leq x_{[n]}$.
3. Compute the statistic

$$D = \frac{\sum_{i=1}^{n} [i - \tfrac{1}{2}(n+1)]\, x_{[i]}}{n^2 s}$$

where

$$s = \left[1/n \sum_{i=1}^{n} (x_i - \bar{x})^2\right]^{1/2} \qquad \text{(standard deviation)}$$

4. Transform D to the statistic Y by computing

$$Y = (D - 0.28209479) / (0.02998598 / n^{1/2})$$

[One should aim for five-place numerical accuracy in computing D (step 3), since the denominator of Y is so small.] If n is large and the data are drawn from a normal distribution, then the expected value of Y is zero. For nonnormal distributions Y will tend to be either less than or greater than zero, depending on the particular distribution. This fact necessitates a two-tailed test (step 5).

5. Reject at the α significance level the null hypothesis that the n data were drawn from a normal distribution if Y is less than the $\alpha/2$ quantile or greater than the $1 - \alpha/2$ quantile of the distribution of Y. These quantiles are given in Table A8 for selected values of n between 50 and 1000 (from D'Agostino, 1971).

The Y statistic can also be used to test the null hypothesis of a lognormal population by using $y_i = \ln x_i$ in place of x_i in the calculations.

Following this procedure for testing the lognormal hypothesis:

$$D = \frac{\sum_{i=1}^{n} [i - ½ (n+1)] \, y_{[i]}}{n^2 s}$$

Where s = standard deviation of the transformed data
$y_i = \ln x_i$ = transformed data

$$s = \left[1/n \sum_{i=1}^{n} (y_i - \bar{y})^2 \right]^{½}$$

$\bar{y}$ = mean of n measurements (transformed data)

s = 1.923824597 (Excel function using transformed data)

Hence the denominator of D is

$$n^2 s = (86)^2 (1.923824597) = 14228.606719412$$

Since (n + 1) / 2 = 87 / 2 = 43.5,

the numerator of D is

$$(1\text{-}43.5)y_{[1]} + (2\text{-}43.5)y_{[2]} + \ldots + (86\text{-}43.5)y_{[86]} = 4032.788836$$

Therefore,

$$D = 4032.788836 / 14228.606719412 = 0.283428$$

Transforming D to the Y statistic by

$$Y = (D - 0.28209479) / (0.02998598 / n^{1/2})$$

$$= (0.283428 - 0.28209479) / (0.02998598 / 86^{1/2}) = 0.41$$

From Table A8: If n =80, the $\alpha / 2 = 0.05 / 2 = 0.025$ quantile is –2.613, and the 1-0.025 = -0.975 quantile is 1.226.

If n=90, Table A8 gives –2.580 and 1.268 for these quantiles.

Linear interpolation between the 0.025 quantiles for n=80 and n=90 gives –2.593 as the approximate 0.025 quantile for n=86.

The 0.975 quantile when n=86 is similarly approximated to be 1.251.

Since Y = 0.41 is not less than –2.593 nor greater than 1.251, the null hypothesis of a lognormal distribution cannot be rejected. Hence, we tentatively accept the hypothesis that the population from which the data were obtained can be approximated by a lognormal distribution.

The distribution is lognormal, now to calculate the concentration term.

"Supplemental Guidance to RAGS: Calculating the Concentration Term," EPA Pub. 9285.7-08, May 1992.

H-statistic (from Selected Tables in Mathematical Statistics, Vol. 3, Ed. by the Institute of Mathematical Statistics, Providence, RI, 1975)

Degree of freedom (dof) = n-1 = 86-1 = 85

Linear interpolation between the standard deviations of 1.75 and 2.00 and between the dofs of 80 and 100 is used to find the H-statistic for an s of 1.92 and dof of 85.

	H		
S	dof=80	dof=85	dof=100
1.75	3.052		2.997
1.92	3.261	3.245	3.200
2.00	3.359		3.295

UCL = Upper 95% Confidence Interval

$$UCL = e^{(\overline{y} + 0.5s^2 + sH / (n-1)^{1/2}}$$

$$= e^{(-1.487 + 0.5(1.92)^2 + (1.92)(3.245) / (86-1)^{1/2})}$$

$$= e^{(-1.487 + 1.843 + 0.676)} = e^{1.032}$$

UCL = 2.8 mg/kg

Pedro Dome Sampling Data (contamination remaining on site)

Sample Results (mg/kg) x_i	Ln(sample) y_i	$[i - \frac{1}{2}(n+1)]\, y_{[i]}$
0.0132	-4.32754	183.9203841
0.0161	-4.12894	171.3508443
0.018	-4.01738	162.7040326
0.019	-3.96332	156.5509938
0.02	-3.91202	150.6128857
0.0201	-3.90704	146.5138299
0.0205	-3.88733	141.8875593
0.0205	-3.88733	138.0002289
0.027	-3.61192	124.6111852
0.028	-3.57555	119.7809508
0.028	-3.57555	116.2054
0.028	-3.57555	112.6298492
0.028	-3.57555	109.0542984
0.029	-3.54046	104.4435537
0.029	-3.54046	100.9030943
0.029	-3.54046	97.36263485
0.029	-3.54046	93.8221754
0.029	-3.54046	90.28171595
0.029	-3.54046	86.7412565
0.03	-3.50656	82.40411059
0.03	-3.50656	78.89755269
0.03	-3.50656	75.39099479
0.03	-3.50656	71.8844369
0.03	-3.50656	68.377879
0.03	-3.50656	64.8713211
0.03	-3.50656	61.3647632
0.031	-3.47377	57.31717323
0.033	-3.41125	52.87433962
0.034	-3.38139	49.03022394
0.044	-3.12357	42.16813621
0.058	-2.84731	35.59140336
0.0707	-2.64931	30.46706162
0.073	-2.6173	27.4816063
0.083	-2.48891	23.64468938
0.12	-2.12026	18.02224006
0.138	-1.9805	14.85376195
0.14	-1.96611	12.77973357
0.147	-1.91732	10.54527481
0.17	-1.77196	7.973805789
0.19	-1.66073	5.812559224

0.21	-1.56065	3.901619371
0.22	-1.51413	2.271191599
0.22	-1.51413	0.757063866
0.23	-1.46968	-0.734837985
0.23	-1.46968	-2.204513955
0.25	-1.38629	-3.465735903
0.29	-1.23787	-4.332560246
0.31	-1.17118	-5.270323417
0.33	-1.10866	-6.097644435
0.35	-1.04982	-6.823843809
0.36	-1.02165	-7.662384356
0.38	-0.96758	-8.224464223
0.4	-0.91629	-8.704761953
0.52	-0.65393	-6.866227908
0.55	-0.59784	-6.875125509
0.55	-0.59784	-7.472962509
0.585	-0.53614	-7.237936329
0.6	-0.51083	-7.406971545
0.78	-0.24846	-3.851151069
0.8	-0.22314	-3.681868597
0.83	-0.18633	-3.260767618
0.97	-0.03046	-0.563495338
1.01	0.00995	0.194031452
1.1	0.09531	1.953858686
1.2	0.182322	3.919913471
1.29	0.254642	5.729449913
1.39	0.329304	7.738638058
1.4	0.336472	8.243569797
1.4	0.336472	8.580042034
1.5	0.405465	10.74482536
1.51	0.41211	11.3330154
1.7	0.530628	15.12290516
2.08	0.732368	21.60485286
2.29	0.828552	25.27083044
2.8	1.029619	32.43301164
2.8	1.029619	33.46263106
3.28	1.187843	39.79275465
4.19	1.432701	49.42817532
4.68	1.543298	54.7870829
4.84	1.576915	57.55738731
5.73	1.745716	65.4643324
5.83	1.763017	67.87615451
5.84	1.764731	69.70686648
PDS9955 1 — 6.38 — 1	1.853168	75.05330794
7 — 6.52 — 7	1.874874	77.8072866
17 — 7.16 — 5 PDS 9977 5517	1.96851	83.66167419

SPBS

		Σ	4032.788836

Column1	
Mean	-1.48712033
Standard Error	0.207451341
Median	-1.491901851
Mode	-3.506557897
Standard Deviation (s)	1.923824597
Sample Variance	3.70110108
Kurtosis	-1.28253459
Skewness	0.2165462
Range	6.29604843
Minimum	-4.327538449
Maximum	1.968509981
Sum	-127.8923484
Count	86
Confidence Level(95.0%)	0.412469093

APPENDIX B – CURRENT ON-SITE RISK

The current on-site risk and hazard index at the former Pedro Dome RRS were calculated using the standard ADEC (ADEC 1999) and EPA (EPA 1996a, 1996b, EPA 1999) equations and residential scenario. The standard EPA input parameters were used except for the following ADEC parameters:

Exposure Frequency (EF) of 270 days / year,

Inverse of the Mean Concentration at the center of a 0.5-acre-square source (Q/C) of 90.8,

Fraction organic carbon (foc) of 0.001,

The only site-specific parameter used was the soil moisture content (w) of 15.7%. This value is based on 67 samples taken during 1996 and falls within the 10% to 20% 'standards.'

Summary of Results:

	Incidental Soil Ingestion	Inhalation of Volatiles	Totals	Totals to One Significant Figure
Aroclor 1260 Risk	6.76E-06	0.174E-6	6.93E-06	7E-06
Aroclor 1260 Hazard	1.38	0.02	1.40	1

The following pages are spreadsheet excerpts showing the risks and hazards, and the physical-chemical data, parameters, and equations used in the calculations.

PHYSICAL-CHEMICAL (PC) DATA AND RISK

CONTAMINANT	Surrogate Chemical if Applicable	H' (dimensionless)	Di (cm^2/s)	Dw (cm^2/s)	Koc (cm^3/g)	Kd (cm^3/g)	S (mg/L-water)	DA (cm^2/s)	VF (m^3/kg)
Aroclor 1260	(Aroclor 1254 for RfDo and RfDi)	1.9E-01	4.4E-02	5.9E-06	6.7E+07	6.700E+04	8.0E-02	2.01E-09	3.691E+06

(The PHYSICAL-CHEMICAL DATA heading spans the columns H' through VF.)

HAVILANDRA:
0.1886 (EPA "PCB RISK ASSESSMENT REVIEW GUIDANCE DOCUMENT" Interim Draft, 12 JAN 2000.)

HAVILANDRA:
0.0441, Calculated after Wilke & Lee.

HAVILANDRA:
5.9E-006 (Montgomery, Groundwater Chemicals, 1996.)

HAVILANDRA:
6,700,00 (EPA "PCB RISK ASSESSMENT REVIEW GUIDANCE DOCUMENT" Interim Draft, 12 JAN 2000.)

HAVILANDRA:
Kd = (Koc) (foc)

HAVILANDRA:
0.08, (EPA "PCB RISK ASSESSMENT REVIEW GUIDANCE DOCUMENT" Interim Draft, 12 JAN 2000.)

TOXICITY INFORMATION							gastro-intestinal abs. factor (A)	Csoil (mg/kg) (conc. in soil)	INGESTION		INHALATION		TOTAL
CSFo 1/(mg/kg-d)		RfDo (mg/kg-d)	CSFi 1/(mg/kg-d)		RfDi (mg/kg-d)				ELCR	HQ	ELCR	HQ	ELCR
2.0E+00	i	2.0E-05	2.0E+00	i	2.0E-05		1.0	2.8	6.76E-06	1.38	1.74E-07	0.02	6.93E-06

SYMBOL	DEFINITION (units)	DEFAULT	INPUT
CSFo	Cancer slope factor oral (1/mg/kg-d)	Chemical Specific	See PC Data & Risk
CSFi	Cancer slope factor inhaled (1/mg/kg-d)	Chemical Specific	See PC Data & Risk
RfDo	Reference dose oral (mg/kg-d)	Chemical Specific	See PC Data & Risk
RfDi	Reference dose inhaled (mg/kg-d)	Chemical Specific	See PC Data & Risk
ELCR	Excess Lifetime Cancer Risk	Calculated	Calculated
HQ	Hazard Quotient	Calculated	Calculated
HI	Hazard Index	Calculated	Calculated
BWa	Body weight, adult (kg)	70	70
BWc	Body weight, child (kg)	15	15
ATc	Averaging time - carcinogens (years)	70	70
ATn	Averaging time - noncarcinogens (days)	ED*365	10950
ATch	Averaging time - child (days)	EDc*365	2190
IRAa	Inhalation rate - adult (m^3/day)	20	20
IRAc	Inhalation rate - child (m^3/day)	10	10
IRSa	Soil ingestion - adult (mg/day)	100	100
IRSc	Soil ingestion - child (mg/day)	200	200
EFr	Exposure frequency - residential (d/y)	350	270
	ADEC under 40-in zone	270	
EDr	Exposure duration - residential (years)	30	30
EDc	Exposure duration - child (years)	6	6
	Age-adjusted factors for carcinogens:		
IFSadj	Ingestion factor, res. soils ((mg-yr)/kg-d))	114	114.28571
InhFadj	Inhalation factor, res. air ((m^3-yr)/(kg-d))	11	10.857143
	Physical Chemical Parameters		
VFs	Volatilization factor (m^3/kg)		
D_A	Apparent diffusivity (cm^2/s)		
Q/C	Inverse of the mean conc. at the center		
	of a 0.5-acre square source		
	(g/m^2-s per kg/m^3)	68.1	90.8
	ADEC under 40-in zone	90.8	
T	Exposure interval (s)	9.50E+08	9.50E+08
p_b	Dry soil bulk density (g/cm^3) (Mg/m^3) (Kg/L)	1.5	1.5
Θ_a	Air filled soil porosity (n - Θ_w) (L_{air}/L_{soil})	0.28	0.1984623
n	Total soil porosity (1 - (p_b / p_s)) (L_{pore}/L_{soil})	0.43	0.4339623
Θ_w	Water-filled soil porosity (w x p_b) (L_{water}/L_{soil})	0.3	0.2355
p_s	Soil particle density (g/cm^3)	2.65	2.65
Di	Diffusivity in air (cm^2/s)	Chemical-specific	See PC Data & Risk
H'	Dimensionless Henry's Law constant	Chemical-specific	See PC Data & Risk
Dw	Diffusivity in water (cm^2/s)	Chemical-specific	See PC Data & Risk
Koc	Soil organic carbon-water partition		
	coefficient (cm^3/g) (L / Kg)	Chemical-specific	See PC Data & Risk
Kd	Soil-water partition coefficient (cm2/g)	Chemical-specific	= (Koc)(foc)
foc	Fraction organic carbon in soil (g/g)		0.001
	EPA	0.006	
	ADEC	0.001	

Csat	Soil saturation concentration (mg/kg)		
S	Solubility in water (mg/L-water)	Chemical-specific	See PC Data & Risk
w	Average soil moisture content	0.1 or 0.2	0.157
	(kg_{water}/kg_{soil} or L_{water}/kg_{soil})		
Cs	Chemical concentration in soil (mg/kg)	site specific	Input
A	Gastrointestinal Absorption factor (unitless)	Chemical-specific	See PC Data & Risk

Modified after EPA R9 PRGs Tables, EPA Soil Screening Guidance, and ADEC 'Equations and Parameters.

ELCR (incidental soil ingeston-residential) =

$$\frac{(Cs)\ (IFSadj)\ (CSFo)\ (EFr)}{(ATc)\ (1E{+}6\ mg/kg)\ (365\ d/yr)}$$

ELCR (inhalation of vapors from soil -residential) =
providing Cs < Csat, otherwise risk at Csat calculated. [For mass limited calculations, use mass-limiting VFs.]

$$\frac{(Cs)\ (EFr)\ (InhFadj)\ (CSFi)}{(ATc)\ (VFs)\ (365\ d/yr)}$$

HQ (incidental soil ingeston-residential) =

$$\frac{(Cs)\ (EFr)\ (EDc)\ (IRSc)}{(BWc)\ (ATch)\ (RfDo)\ (1E{+}6\ mg/kg)}$$

HQ (inhalation of vapors from soil -residential) =
providing Cs < Csat, otherwise HQ at Csat calculated. [For mass limited calculations, use mass-limiting VFs.]

$$\frac{(Cs)\ (EFr)\ (EDc)\ ((1/RfDi)\ (IRAc/VFs))}{(BWc)\ (ATch)}$$

IFSadj (incidental ingestion soil age adj, child/adult) =

$$\frac{(EDc)\ (IRSc)}{BWc} + \frac{(EDr - EDc)\ (IRSa)}{BWa}$$

InhFadj (inhalation age adj.) =

$$\frac{(EDc)\ (IRAc)}{BWc} + \frac{(EDr - EDc)\ (IRAa)}{BWa}$$

VFs (infinite source) =

$$(Q/C)\ \frac{[(3.14)\ (D_A)\ (T)]^{1/2}}{(2)\ (p_b)\ (D_A)}\ (1E{-}4\ m^2/cm^2)$$

D_A =

$$\frac{[((\theta a^{10/3})\ (Di)\ (H') + (\theta w^{10/3})\ (Dw))\ /\ n^2]}{(p_b)\ (Kd) + \theta w + (\theta a)\ (H')}$$

VFs (Mass limiting) =

$$(Q/C)\ [\ (T)\ /\ [(p_b)\ (ds)\ (1E{+}6\ g/Mg)]\ ]$$

Csat (soil saturation conc.) =

$$(S\ /\ p_b)\ [(Kd)\ (p_b) + \theta w + (H')\ (\theta a)]$$